

What is claimed is:

1. An isolated nucleic acid molecule comprising a sequence encoding an enzyme that desaturates an n-6 fatty acid to a corresponding n-3 fatty acid, wherein the sequence 5 includes at least one optimized codon.
2. The isolated nucleic acid molecule of claim 1, wherein the sequence is a *C. elegans* *fat-1* gene.
- 10 3. The isolated nucleic acid molecule of claim 2, wherein the sequence includes at least 5 and up to 150 optimized codons.
- 15 4. The isolated nucleic acid molecule of claim 2, wherein 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, 35-40, 40-45, 45-50, 50-55, 55-60, 60-65, 65-70, 70-75, 75-80, 80-85, 85-90, 90-95, 95-100, 100-105, 105-110, 110-115, 115-120, 120-125, 125-130, 130-135, 135-140, 140-145, or 145-150 of the codons are optimized.
- 20 5. The isolated nucleic acid molecule of any of claim 1, comprising an optimized codon at position 6, 9, 18, 20, 22, 24, 28-30, 33-36, 47, 49, 52, 54, 58, 60, 61, 64, 67, 69-71, 73, 77, 79, 81, 86, 89, 92, 94-95, 100, 101, 105, 106, 112, 115, 118, 124, 127, 128, 131, 146, 151, 154, 161, 163, 164, 169, 178, 187, 188, 195, 197, 200, 202, 206, 210, 214, 217, 221, 223, 225, 227, 228, 232, 234, 241, 245, 255, 271, 280-282, 284, 285, 301, 303, 310, 312, 327, 362, or 370.
- 25 6. The isolated nucleic acid molecule of claim 2, comprising the sequence of the nucleic acid shown in Fig. 18.
- 30 7. The isolated nucleic acid molecule of claim 1, further comprising a nucleic acid sequence encoding a therapeutic polypeptide.
8. The isolated nucleic acid molecule of claim 1, further comprising a regulatory element or a nucleic acid sequence encoding a marker.

9. The isolated nucleic acid molecule of claim 8, wherein the regulatory element is a tissue-specific promoter.

10. An expression vector comprising the nucleic acid sequence of claim 1.

5

11. The expression vector of claim 10, wherein the vector is a viral vector.

12. The expression vector of claim 11, wherein the viral vector is a retroviral or adenoviral vector.

10

13. The expression vector of claim 10, wherein the vector is a plasmid.

14. A host cell comprising the nucleic acid molecule of claim 1.

15 15. A host cell comprising the expression vector of claim 10.

16. A pharmaceutical composition comprising the expression vector of claim 10 and a physiologically acceptable diluent.

20 17. A non-human transgenic animal comprising the nucleic acid molecule of claim 1.

18. The non-human transgenic animal of claim 17, wherein the animal is a mammal, a bird, or a fish.

25 19. The non-human transgenic animal of claim 18, wherein the mammal is a cow, a pig, or a sheep; the bird is a chicken, a turkey, a duck, a goose, or a game hen; and the fish is a salmon, trout, or tuna.

20. A food product or dietary supplement comprising the non-human transgenic animal of
30 claim 17 or a tissue or processed part thereof.

21. A method of improving the content of n-3 fatty acids in a subject's diet, the method comprising administering to the subject the food product or dietary supplement of claim 20.

5 22. A method of treating a patient who has been diagnosed as having cancer, the method comprising administering to the patient a therapeutically effective amount of the nucleic acid molecule of claim 1.

10 23. The method of claim 22, wherein the cancer is breast cancer, colon cancer, prostate cancer, liver cancer, cervical cancer, lung cancer, brain cancer, skin cancer, stomach cancer, head and neck cancer, pancreatic cancer, a blood cancer, or ovarian cancer.

15 24. A method of inhibiting neuronal cell death in a subject, the method comprising administering to the subject a therapeutically effective amount of the nucleic acid molecule of claim 1.

25. The method of claim 24, wherein the subject has been diagnosed as having a neurodegenerative disease.

20 26. The method of claim 25, wherein the neurodegenerative disease is Alzheimer's disease, Parkinson's disease, or Huntington's disease.

25 27. A method of treating a subject who has, or who may develop, a condition associated with an insufficiency of n-3 polyunsaturated fatty acid (PUFA) or an imbalance in the ratio of n-3:n-6 PUFAs, the method comprising administering to the subject the nucleic acid molecule of claim 1.

30 28. The method of claim 27, wherein the condition is an arrhythmia, cardiovascular disease, cancer, an inflammatory disease (e.g., an inflammatory vascular disease such as atherosclerosis or a vascular condition such as restenosis), an autoimmune disease, a skin malformation or threatened malformation of the retina or brain, diabetes, obesity, a skin disorder, a renal disease, ulcerative colitis, Crohn's disease, or chronic obstructive pulmonary disease.

29. A method of treating a subject who has received, or who is scheduled to receive, a transplant comprising a biological organ, tissue, or cell, the method comprising administering to either the subject or the transplant, the nucleic acid molecule of claim 1.

5

30. A transgenic fish comprising a nucleic acid sequence encoding an enzyme that desaturates an n-6 fatty acid to a corresponding n-3 fatty acid.

31. The transgenic fish of claim 30, wherein the fish is cod or any fish of the family 10 Gadidae, order Gadiformes; halibut; herring or any fish of the order Clupeiformes; mackerel or any fish in the family Scombridae; salmon or any fish of the Salmonidae family, including trout; perch or any fish of the family Percidae; shad or any fish of the family Clupeidae; skate or any fish of the family Rajidae; smelt or any fish of the family 15 Osmeridae; sole or any fish of the family Soleidae; and tuna or any fish of the family Scombridae.

32. The transgenic fish of claim 30, wherein the nucleic acid sequence comprises a *C. elegans fat-1* gene.

20 33. The transgenic fish of claim 32, wherein the *C. elegans fat-1* gene contains at least one optimized codon.

34. The transgenic fish of claim 33, wherein the sequence includes at least 5 and up to 150 optimized codons.

25

35. The transgenic fish of claim 33, wherein 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, 35-40, 40-45, 45-50, 50-55, 55-60, 60-65, 65-70, 70-75, 75-80, 80-85, 85-90, 90-95, 95-100, 100-105, 105-110, 110-115, 115-120, 120-125, 125-130, 130-135, 135-140, 140-145, or 145-150 of the codons are optimized.

30

36. The transgenic fish of claim 33, wherein the nucleic acid comprises an optimized codon at position 6, 9, 18, 20, 22, 24, 28-30, 33-36, 47, 49, 52, 54, 58, 60, 61, 64, 67, 69-71, 73, 77, 79, 81, 86, 89, 92, 94-95, 100, 101, 105, 106, 112, 115, 118, 124, 127, 128,

131, 146, 151, 154, 161, 163, 164, 169, 178, 187, 188, 195, 197, 200, 202, 206, 210, 214, 217, 221, 223, 225, 227, 228, 232, 234, 241, 245, 255, 271, 280-282, 284, 285, 301, 303, 310, 312, 327, 362, or 370.

5 37. The transgenic fish of claim 33, wherein the nucleic acid comprises the sequence of the nucleic acid shown in Fig. 18.

38. A transgenic bird comprising a nucleic acid sequence encoding an enzyme that desaturates an n-6 fatty acid to a corresponding n-3 fatty acid, and wherein the bird is bred 10 for consumption.

39. The transgenic bird of claim 38, wherein the bird is a chicken, a turkey, a duck, a goose, or a game hen.

15 40. The transgenic bird of claim 38, wherein the nucleic acid sequence comprises a *C. elegans fat-1* gene.

41. The transgenic bird of claim 40, wherein the *C. elegans fat-1* gene contains at least one optimized codon.

20 42. The transgenic bird of claim 41, wherein the *C. elegans fat-1* gene includes at least 5 and up to 150 optimized codons.

43. The transgenic bird of claim 42, wherein 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, 35-25 40, 40-45, 45-50, 50-55, 55-60, 60-65, 65-70, 70-75, 75-80, 80-85, 85-90, 90-95, 95-100, 100-105, 105-110, 110-115, 115-120, 120-125, 125-130, 130-135, 135-140, 140-145, or 145-150 of the codons are optimized.

44. The transgenic bird of claim 41, wherein the *C. elegans fat-1* gene comprises an 30 optimized codon at position 6, 9, 18, 20, 22, 24, 28-30, 33-36, 47, 49, 52, 54, 58, 60, 61, 64, 67, 69-71, 73, 77, 79, 81, 86, 89, 92, 94-95, 100, 101, 105, 106, 112, 115, 118, 124, 127, 128, 131, 146, 151, 154, 161, 163, 164, 169, 178, 187, 188, 195, 197, 200, 202, 206,

210, 214, 217, 221, 223, 225, 227, 228, 232, 234, 241, 245, 255, 271, 280-282, 284, 285,
301, 303, 310, 312, 327, 362, or 370.

45. The transgenic bird of claim 41, wherein the *C. elegans fat-1* gene comprises the
5 sequence shown in Fig. 18.